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SDC
SOLENOIDAL DETECTOR NOTES

PARTICLE RATES AND PUNCH-THROUGH RATES FOR THE SDC DETECTOR

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Particle Rates and Punch-through Rates for the SDC Detector

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ABSTRACT

By using ISAJET event generator, the number of generated pions for different P_t limits for primary jets are compared. It is shown that valid P_t limits must be made clear in order to get a reliable number of pions in the forward region. The pseudo-rapidity distribution and the momentum distribution of pions are given, when the P_t limits for the primary jets are taken between 1 GeV/c and 200 GeV/c.

The number of decay muons is given for the SDC detector (type I), before entrance to the calorimeter. This is in agreement with the previous work by Y. Sakai (1), although the assumptions are somewhat different.

A new empirical formula for the pion punch-through probability is given, and it is compared with other formulas. They differ orders of magnitude with each other in certain ranges of momentum. By using this formula, the number of pions punching-through the iron absorber is computed, and data are compared with the previous work (1). They are consistent with each other at higher momenta, but differ by a factor of 5 at lower momenta.

Introduction

To estimate the number of particles produced in peripheral collisions at the SSC is important to calculate the background rates, trigger requirements, detector occupancies, lepton isolation, and so on. It is known that the "MINBIAS" event generation in ISAJET is not suitable for this purpose; "TWOJET" with low P_t limits for primary jets is generally used instead. It is not clear, however, how low these limits ought to be. One criterion would be, if the total cross-section approaches the expected one (~100mb) the limits are low enough[(1)]. What if the limits are further lowered ? Does this represent unphysical events or very peripheral collisions ? As the code does produce events at lower P_t limits, a comparison was made for different P_t limits.

Hadron punch-through probabilities are formulated[(2), (3)] for different energy and absorber thickness regions. They reproduce data very well for limited regions, but differ with each other by orders of magnitude outside of their valid regions. In ref. (1), for example, the punch-through probability is taken as the larger of the WA1 and Lang fit. Recently, new data became available[(4)]. By using these data, a new empirical formula was devised; the new formula is compared with other formulas. Punch-through probabilities are calculated using this formula, and by using the pion rates for the P_t range of primary jets between 1 and 200 GeV/c, the punch-through rates are calculated for the SDC detector, at the exit of the calorimeter (equivalent to 2m of iron) and the results are compared with the results of ref. (1).

Event generation.

Table 1 shows the raw data of generated events for the P_t ranges of primary jets: $1 \leqq P_t \leqq 5$, $5 \leqq P_t \leqq 20$ and $20 \leqq P_t \leqq 200$ (GeV/c). It should be noted that the cross-section is approximately 100mb for $P_t \geqq 5$; that's why the P_t range $5 \leqq P_t \leqq 200$ was chosen in ref. (1). The cross-section becomes larger by more than 10 times, if the P_t range is lowered to 1 GeV/c. Table 2 shows the data which are normalized to $1mb^{-1}$ of luminosity. It is seen that the number of pions generated within $|y| \leqq 1.5$ is roughly the same for the P_t limit of the primary jets $1 \leqq P_t \leqq 5$ and $5 \leqq P_t \leqq 20$. This may assure that events generated for the P_t limit $5 \leqq P_t$ may well represent the minimum biased events for $|y| \leqq 1.5$. However, the number of pions generated within $|y| \leqq 3$ differs 10 times between the P_t limit $1 \leqq P_t \leqq 5$ and $5 \leqq P_t \leqq 20$. We are no more confident whether events generated for the P_t limit $5 \leqq P_t$ represent the minimum biased events or not. There must be some reason to set the lower limit in order to have a reliable estimation of the minimum biased events.

Although there is no reason why, in the following analysis the lower P_t limit of the primary jets was chosen as 1GeV/c, and events were added for three ranges of P_t limit: $1 \leqq P_t \leqq 5$, $5 \leqq P_t \leqq 20$ and $20 \leqq P_t \leqq 200$.

Pion Rates and decay muons.

Figure 1 shows the number of charged pions with momenta greater than 5 GeV/c produced per $1mb^{-1}$ of luminosity within pseudo-rapidity bin of 0.1 as a function of the pseudo-rapidity. The events are broken up for three ranges of the P_t limit of primary jets. The figure might imply that the numbers are underestimated by an order of magnitude if the lower P_t range is taken as 5GeV/c instead of 1GeV/c, for $|y| \geqq 2$; or it might imply, instead, that the events for P_t range $1 \leqq P_t \leqq 5$ could be unphysical. The author would be glad if someone answers this question. Figures 2–7 show the similar quantities. In figures 4–7, the pseudo-rapidity bin is enlarged to 0.5, due to a poor statistics. Figure 8 shows the momentum distribution of pions with momenta greater than 5GeV/c, for $0 \leqq y \leqq 1.5$; Fig. 9 for $1.5 \leqq y \leqq 2.5$. The number of kaons is roughly 6 times smaller than the number of pions. By using the generated pions and kaons, the distribution of decay muons was calculated. Figure 10 shows the number of decay muons at the entrance of the calorimeter for the type I of the SDC detector. In the figure, the cross marks represent the data shown in Fig. 7 of ref. 1. Although the assumptions are somewhat different, they are in general agreement.

Pion punch-through rates.

By using the recently published data by Sandler et al.[4], an empirical formula for the punch-through probability is devised (formula A):

$$P = exp[-(t-25.6E^{0.35})/(14.9E^{0.165})] + 4\times10^{-3} exp[0.0048E-0.003t]$$

Here, t denotes the thickness of iron in cm, E denotes the energy (or momentum) of the pion. The first term is essentially identical to the WA1 parametrization[2]; the second term represents the tail, a part of which is caused by the muon generation[4]. The formula is compared with data points in Fig. 11. The formula represents the data of ref. (4) reasonablly well, including the tail. It is also compared with other data at 5GeV and

250GeV. The agreement is not so good, but the disagreement is not larger than 100%. This is an improvement since the formula can be used for the pion energy anywhere between 5GeV and 250GeV, and the iron thickness between 200cm and 600cm, within an accuracy of a factor of 2.

In Fig. 12, which was taken from ref. (1), the formula A is compared with other formulas. They differ with each other by orders of magnitude.

By using the formula A, punch-through probabilities are calculated in Fig. 13 as a function of pion momentum. In Fig. 14, they are calculated as a function of iron thickness.

Finally, by using the formula A and the pion rates mentioned earlier, pion punch-through rates are calculated for $0 \leqq y \leqq 1.5$. The data are compared with those given in Fig. 15 of ref. (1). They are in agreement for higher momenta, but they differ by a factor of 5 at lower momenta, due primarily to the difference in the pion rates, which is caused by the difference in the lower P_t limit for the primary jets at event generation.

References.

(1) Y. Sakai, Proceedings of the International Workshop on Solenoidal Detectors for the SSC, KEK(1990) p. 421.

(2) "SSC Muon Detector Group Report", page 405 in Snowmass 1986 Proceedings.

(3) A. Bodek, UR911 ER13065-412(1985).

(4) P. H. Sandler et al. WISC-EX-89-306.

Figure captions.

Fig. 1 Number of charged pions per (milibarn^{-1}. 0.1 of pseudo-rapidity). Events are broken up in three ranges of P_t limits for primary jets ("TWOJET" in ISAJET). $P \geq 5 GeV/c$.

Fig. 2 The same as above, $10 \geq P \geq 5$.

Fig. 3 The same as above, $15 \geq P \geq 10$.

Fig. 4 Number of charged pions per (milibarn^{-1}. 0.5 of pseudo-rapidity), $20 \geq P \geq 15$.

Fig. 5 The same as above, $50 \geq P \geq 20$.

Fig. 6 The same as above, $100 \geq P \geq 50$.

Fig. 7 The same as above, $P \geq 100$.

Fig. 8 Momentum distribution of charged pions with $P \geq 5$, $1.5 \geq y \geq 0$.

Fig. 9 Momentum distribution of charged pions with $P \geq 5$, $2.5 \geq y \geq 1.5$.

Fig. 10 Number of decay muons with $P \geq 5$ before entrance to the calorimeter, type I of SDC.

Fig. 11 Punch-through probability, data points and calculated curves with formula A.

Fig. 12 Comparison of punch-through formulas. Formula A is added to Fig. 2 of ref. (1).

Fig. 13 Pion punch-through probability calculated with formula A, as a function of pion momentum.

Fig. 14 Pion punch-through probability calculated with formula A, as a function of iron thickness.

Fig. 15 Pion punch-through rates per (1mb^{-1}·5GeV/c) after 2m of iron.

Table 1

EVENT GENERATION

Pt range of jets (GeV/c)	Number of generated events	Corresponding luminosity (mb inv.)	Number of pions								Number of decay muons $5\leq P$
				$5\leq P$	$5<P\leq 10$	$10<P\leq 15$	$15<P\leq 20$	$20<P\leq 50$	$50<P\leq 100$	$100<P$	
$1\leq Pt\leq 5$	5,000	3.9	$\lvert y\rvert <1.5$	14	13	0	0	0	0	1	0.2
			$\lvert y\rvert <3$	12,310	9,550	810	132	26	15	1,777	161
			$\lvert y\rvert <5$	138,309	48,638	27,490	16,351	28,550	4,068	13,212	1,049
$5\leq Pt\leq 20$	2,000	22.6	$\lvert y\rvert <1.5$	133	100	10	1	0	0	22	1.6
			$\lvert y\rvert <3$	6,355	4,675	578	122	88	7	885	85
			$\lvert y\rvert <5$	59,364	20,779	11,685	6,945	12,446	2,000	5,509	450
$20\leq Pt\leq 200$	500	210	$\lvert y\rvert <1.5$	345	222	51	16	10	1	45	3.8
			$\lvert y\rvert <3$	3,216	2,098	424	155	215	32	292	37
			$\lvert y\rvert <5$	19,892	7,284	3,707	2,270	4,148	829	1,654	161

Table 2

LUMINOSITY-NORMALIZED NUMBER OF EVENTS

Pt range of jets (GeV/c)	Pseudo rapidity	Number of pions per 1mb inv.							Number of decay muons
		$5\leq P$	$5<P\leq 10$	$10<P\leq 15$	$15<P\leq 20$	$20<P\leq 50$	$50<P\leq 100$	$100<P$	
$1\leq Pt\leq 5$	$\lvert y\rvert <1.5$	3.6	3.3	0	0	0	0	0.26	0.05
	$\lvert y\rvert <3$	3,156	2,449	208	34	6.7	3.8	456	41
	$\lvert y\rvert <5$	35,464	12,471	7,049	4,192	7,320	1,043	3,388	269
$5\leq Pt\leq 20$	$\lvert y\rvert <1.5$	5.9	4.4	0.4	0.04	0	0	0.97	0.07
	$\lvert y\rvert <3$	281	207	25	5.4	3.9	0.31	39	3.8
	$\lvert y\rvert <5$	2,627	919	517	307	551	88	244	20
$20\leq Pt\leq 200$	$\lvert y\rvert <1.5$	1.6	1.1	0.24	0.07	0.05	0.005	0.21	0.02
	$\lvert y\rvert <3$	15.3	10	2	0.74	1	0.15	1.4	0.18
	$\lvert y\rvert <5$	95	35	18	11	20	3.9	7.9	0.77

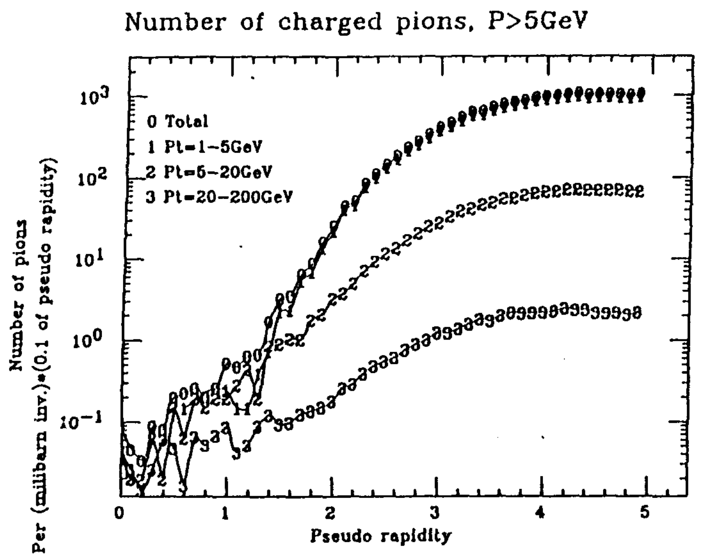


Fig. 1

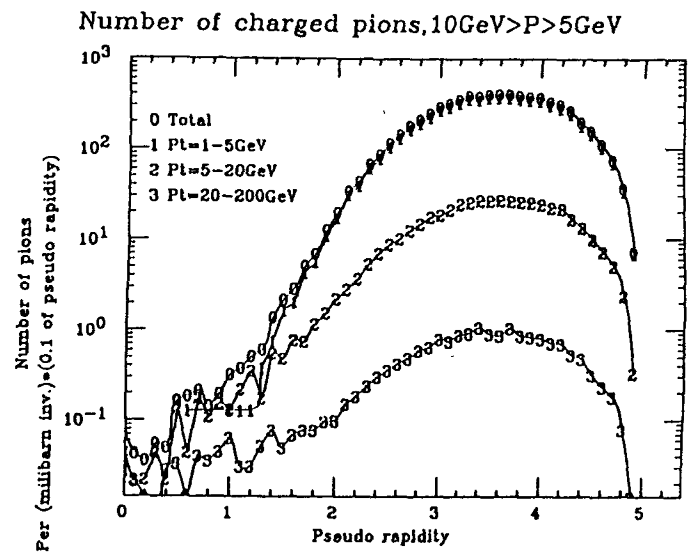


Fig. 2

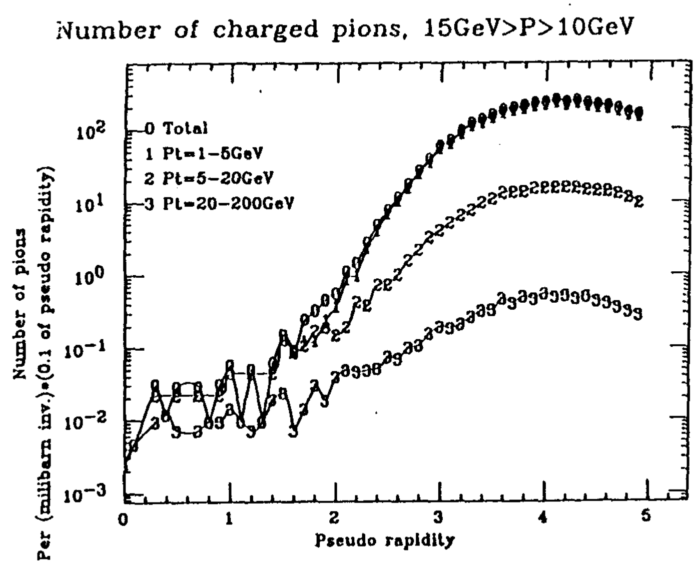


Fig. 3

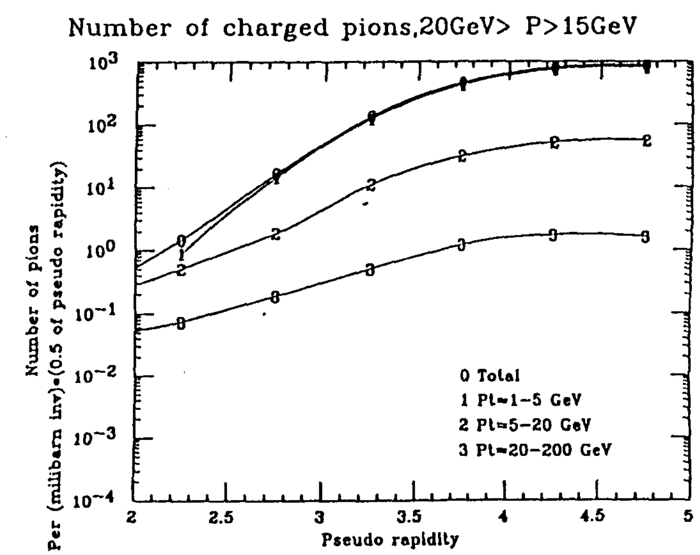


Fig. 4

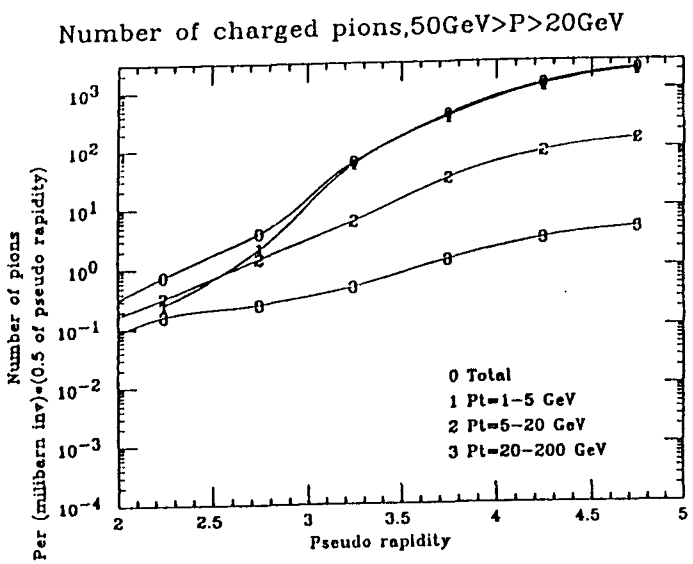


Fig. 5

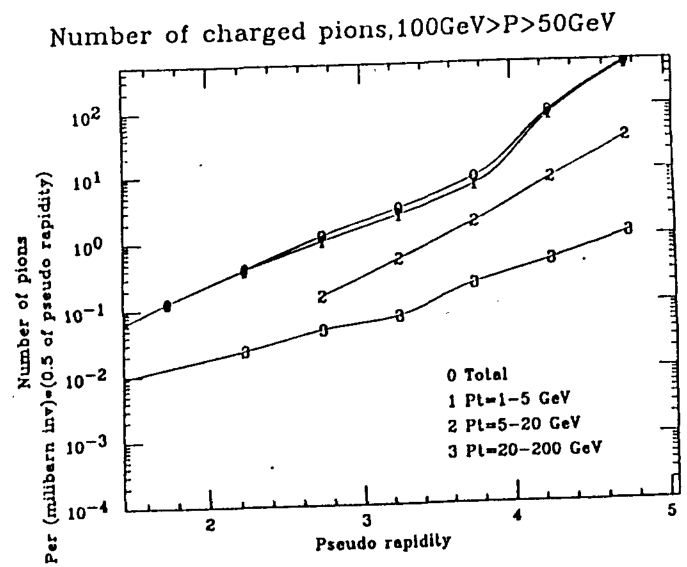


Fig. 6

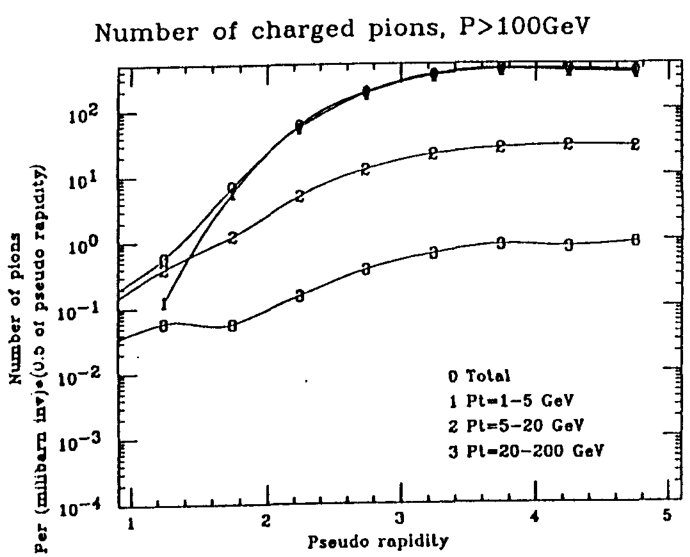


Fig. 7

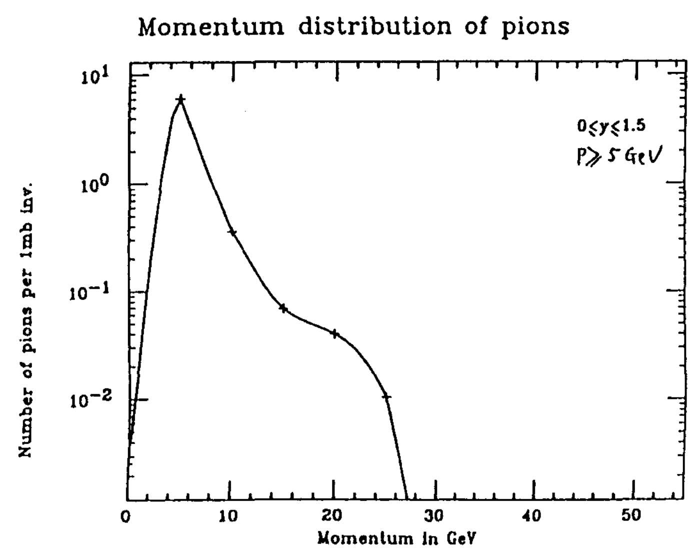


Fig. 8

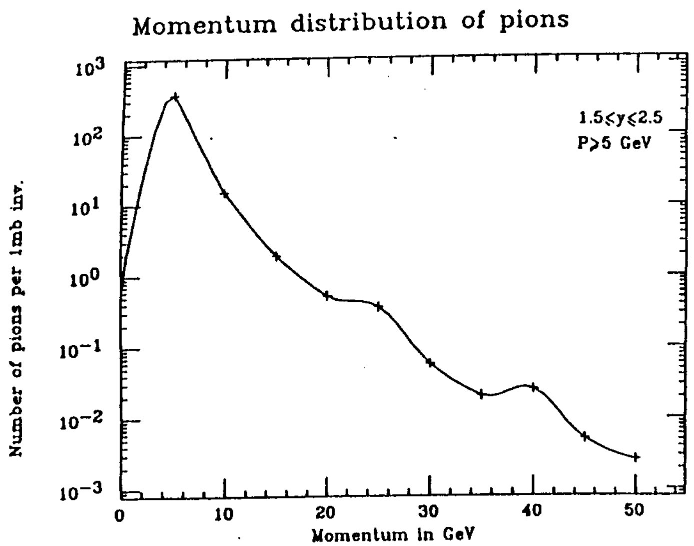


Fig. 9

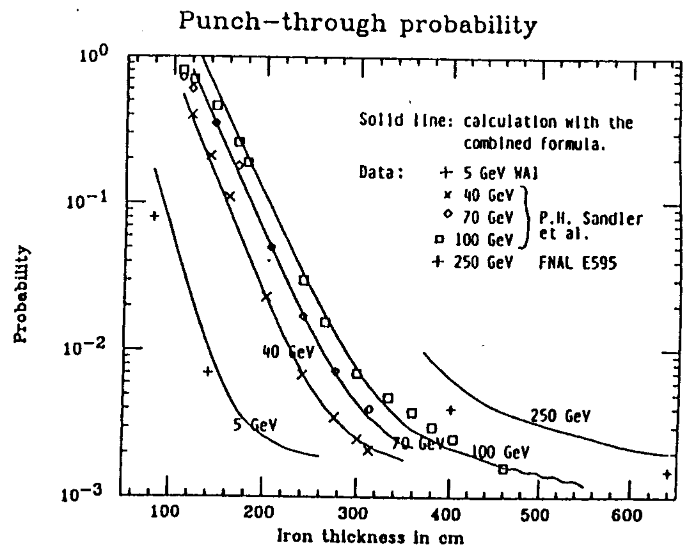


Fig. 11

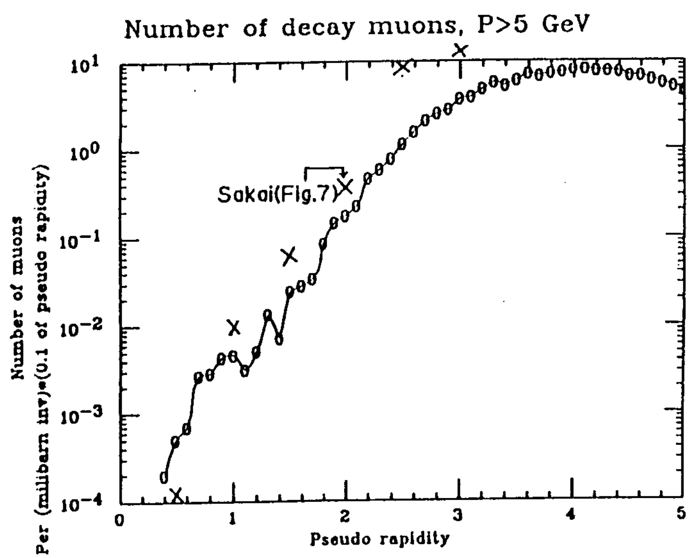
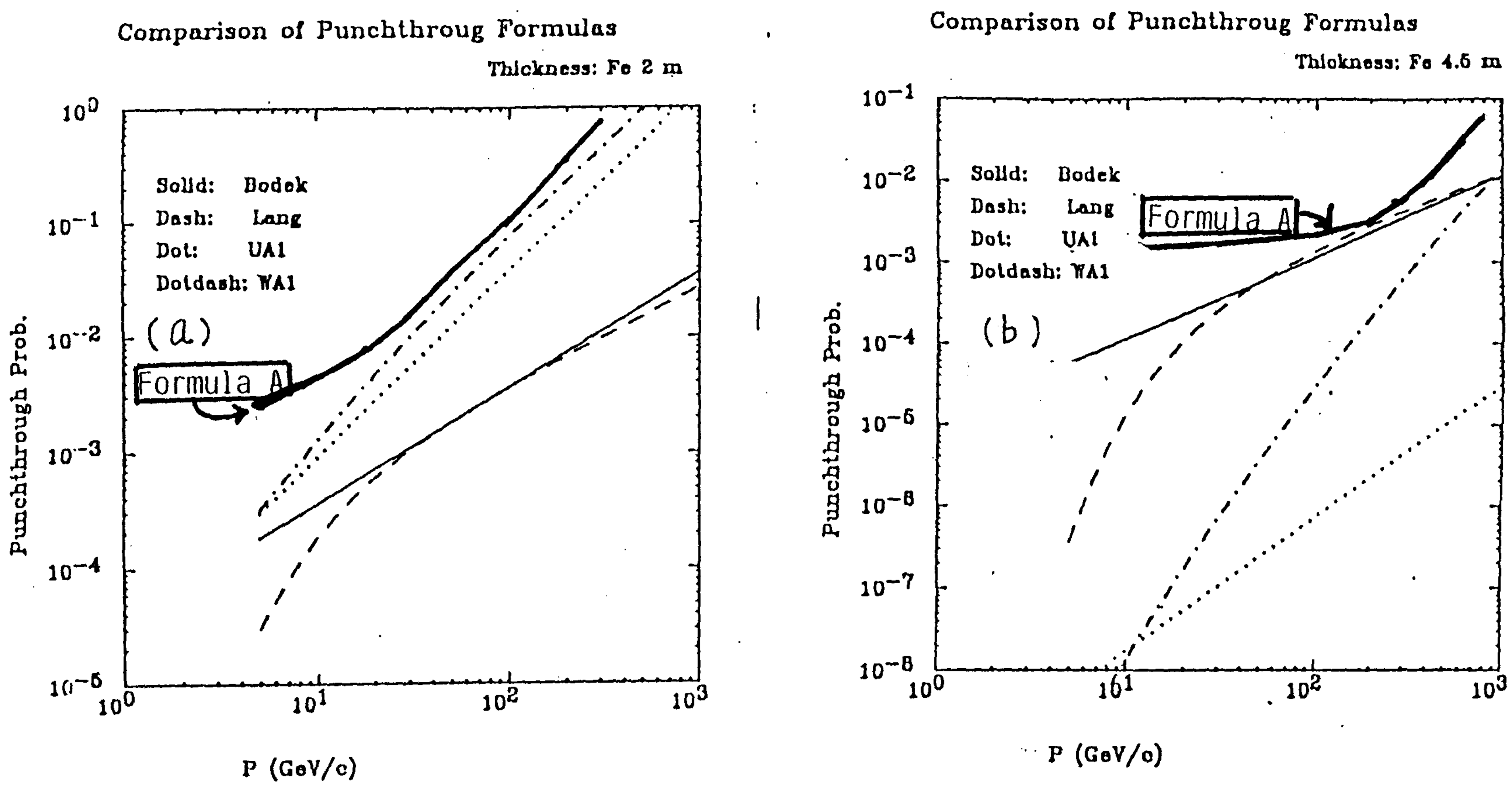


Fig. 10


Comparison of Punchthroug Formulas
Thickness: Fe 2 m
Solid: Bodek
Dash: Lang
Dot: UA1
Doldash: WA1
(a)
Formula A
Punchthrough Prob.
P (GeV/c)
Comparison of Punchthroug Formulas
Thickness: Fe 4.5 m
Solid: Bodek
Dash: Lang
Dot: UA1
Doldash: WA1
(b)
Formula A
Punchthrough Prob.
P (GeV/c)

(Sakai)

Fig. 12

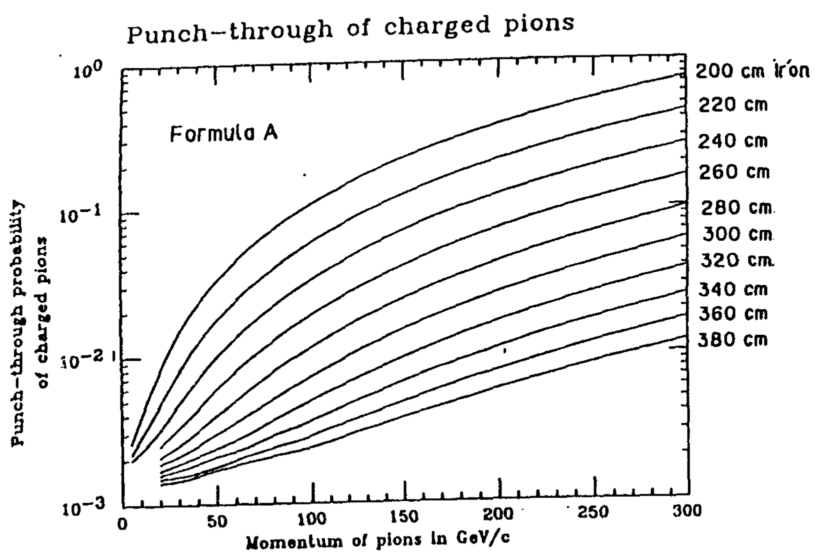


Fig. 13

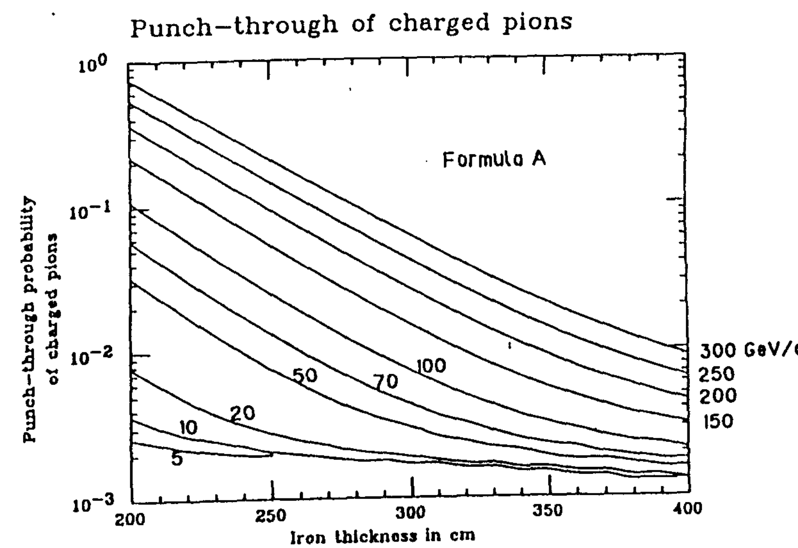


Fig. 14

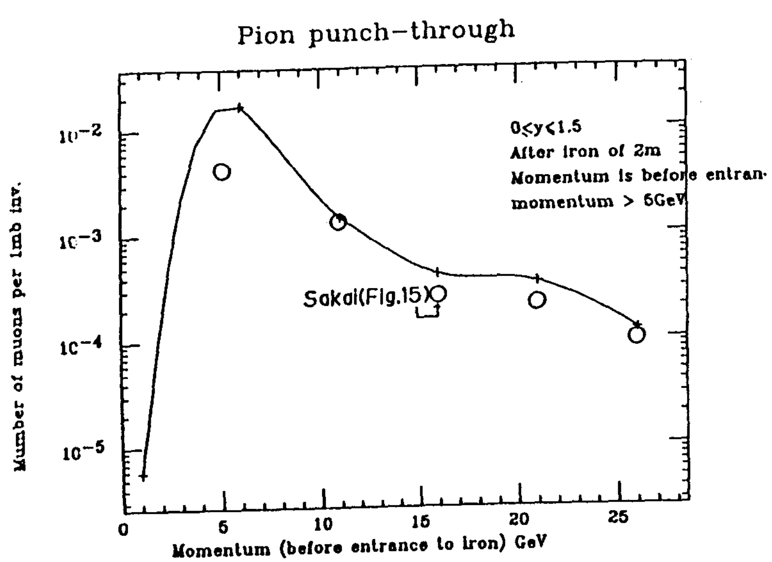


Fig. 15